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(54) **METHOD FOR TRANSMITTING SIGNAL USING PLURALITY OF ANTENNA PORTS AND TRANSMISSION END APPARATUS FOR SAME**

(58) **Field of Classification Search**

None

See application file for complete search history.

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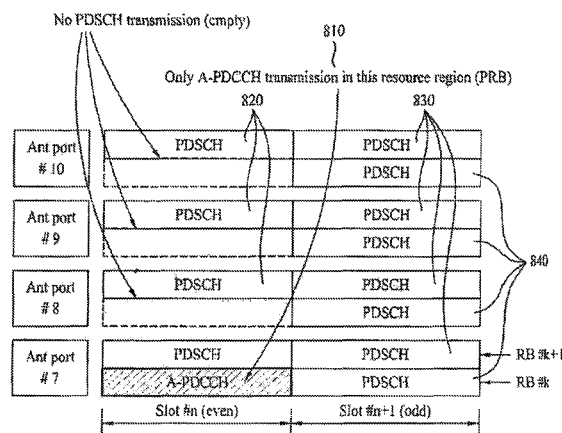
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(57) **ABSTRACT**

A method for transmitting a signal by using a plurality of antenna ports and a transmission end apparatus for same are disclosed. A method for transmitting the signal using the plurality of antenna ports, according to the present invention, comprises the following steps: transmitting a control channel to a reception end through a first antenna using a first resource domain; and transmitting a data channel to the reception end through the plurality of antenna ports including first antenna port using a second resource domain, wherein the second resource domain and the first resource domain have identical time domains but different frequency domains, and wherein from the time and frequency domains that belong to the first resource domain, the data channel is not transmitted through at least one antenna port from the antenna ports excluding the first antenna port.

**12 Claims, 8 Drawing Sheets**



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FIG. 1

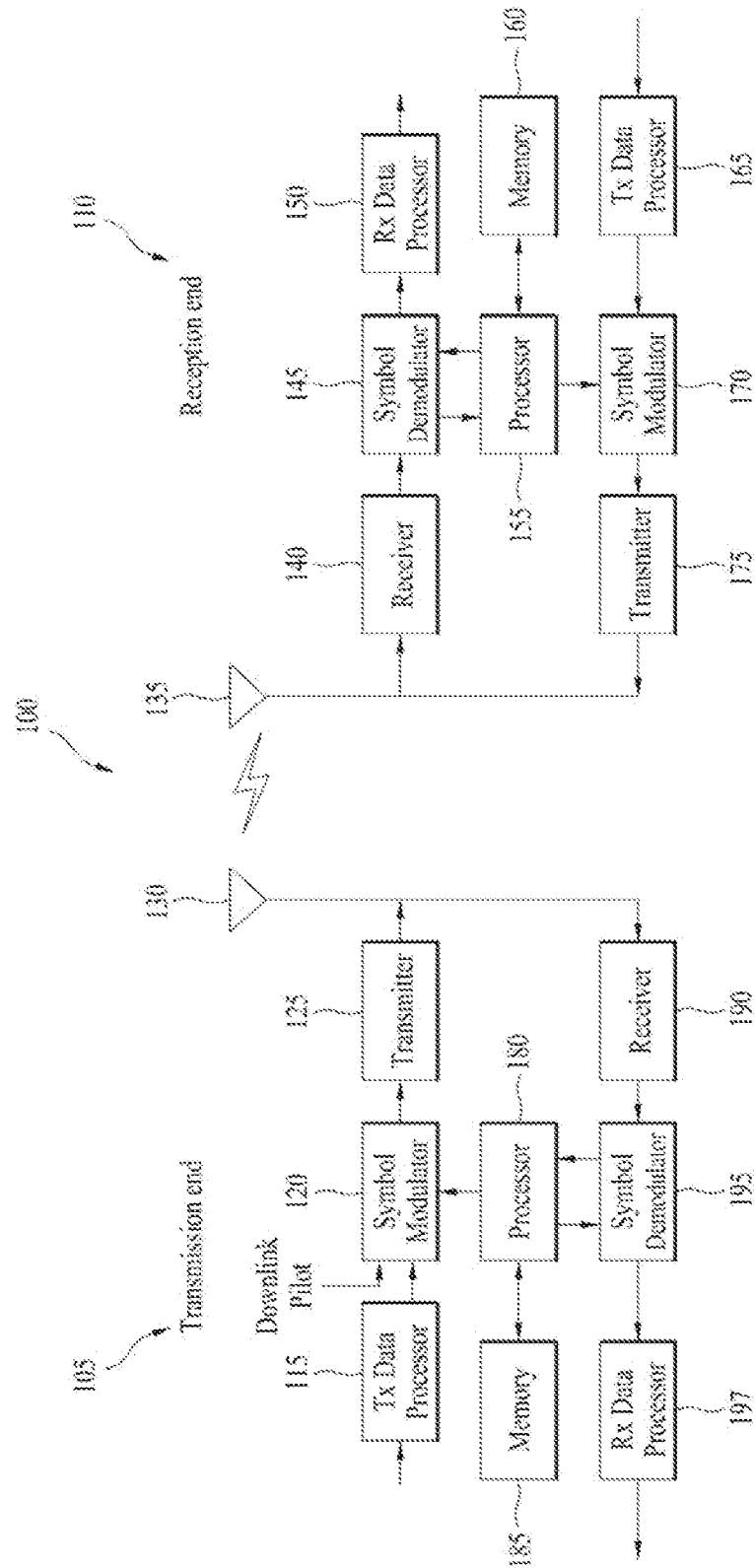


FIG. 2

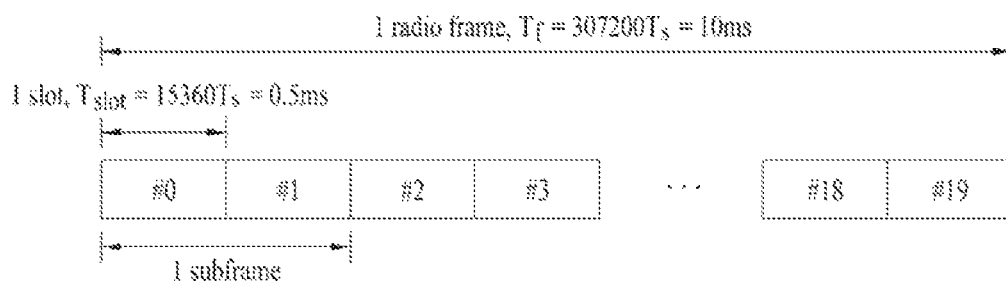
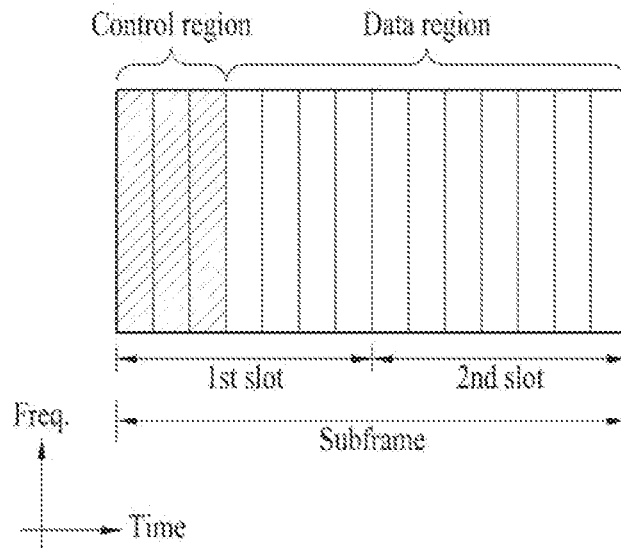
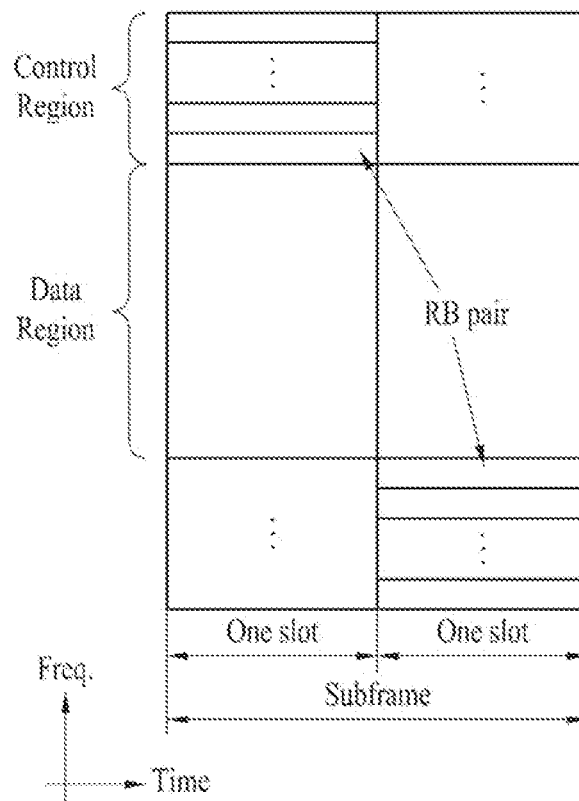


FIG. 3



(a)



(b)

FIG. 4

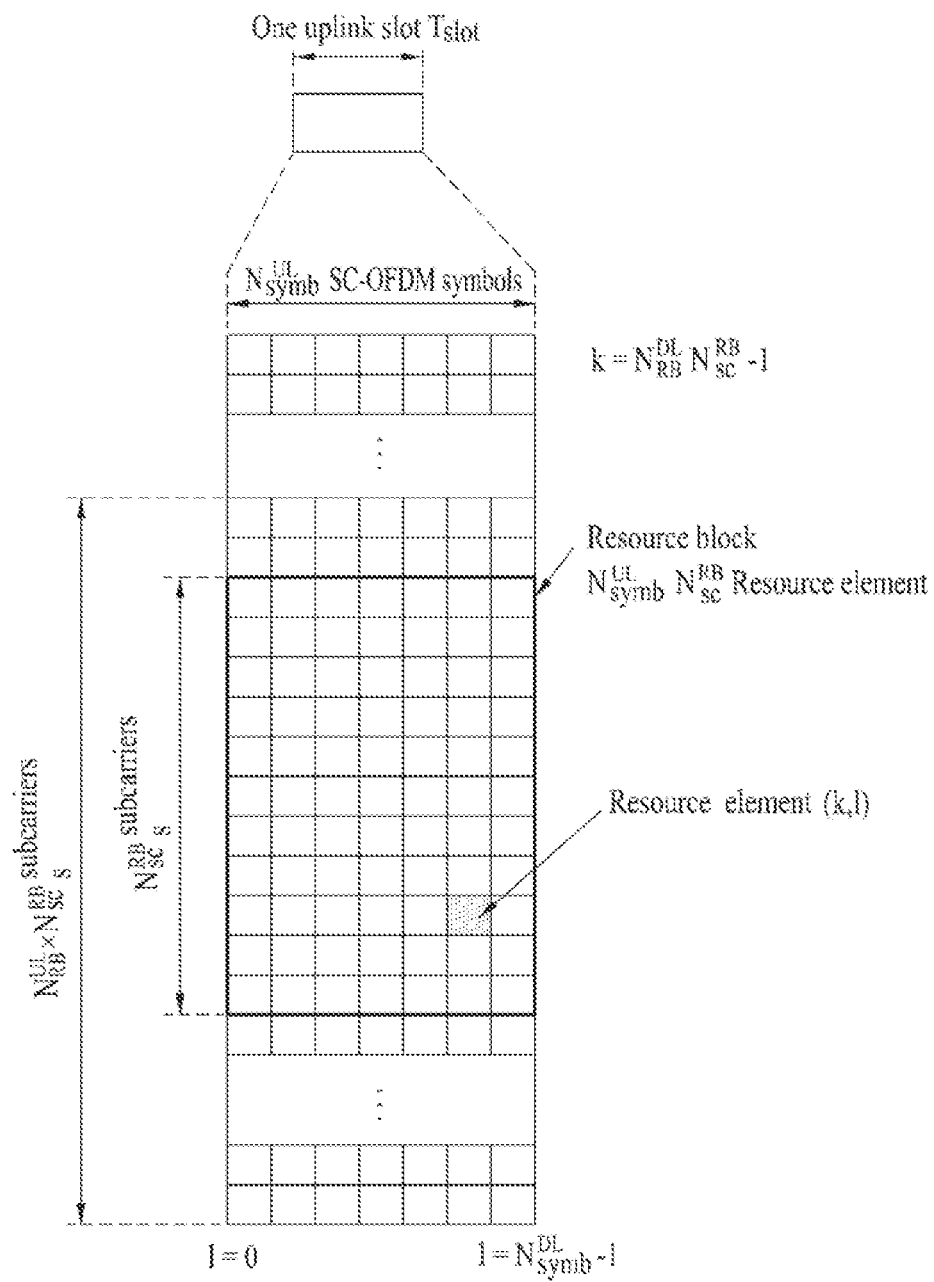


FIG. 5

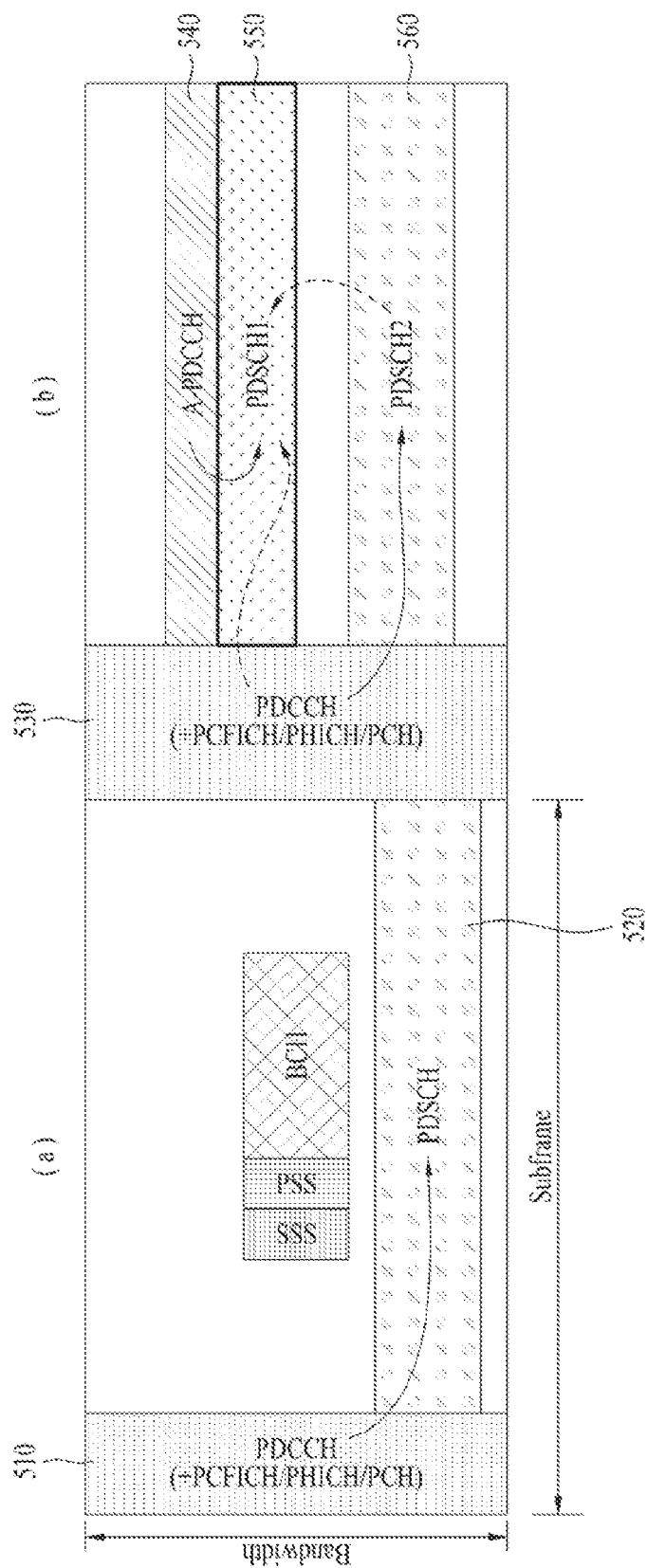


FIG. 6

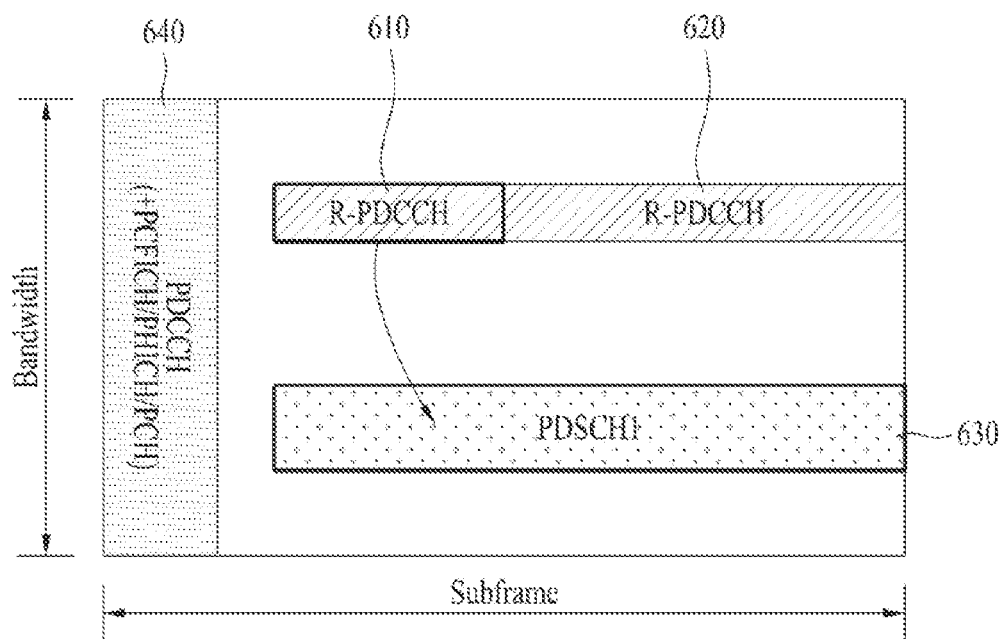




FIG. 7

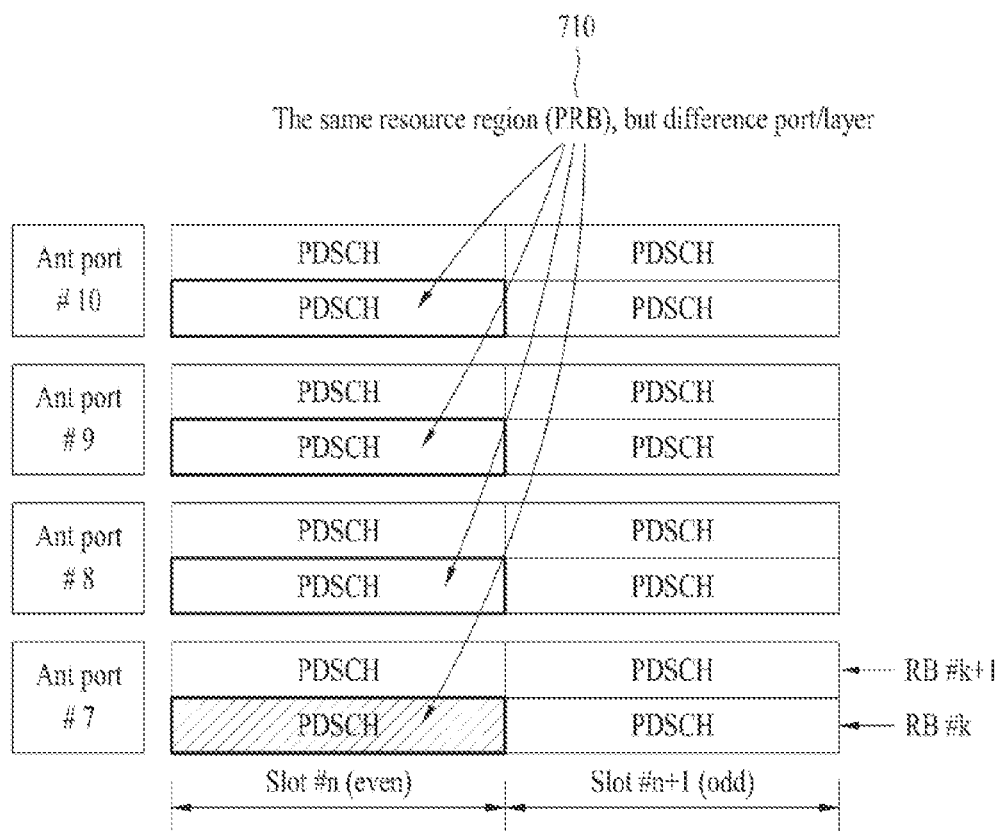
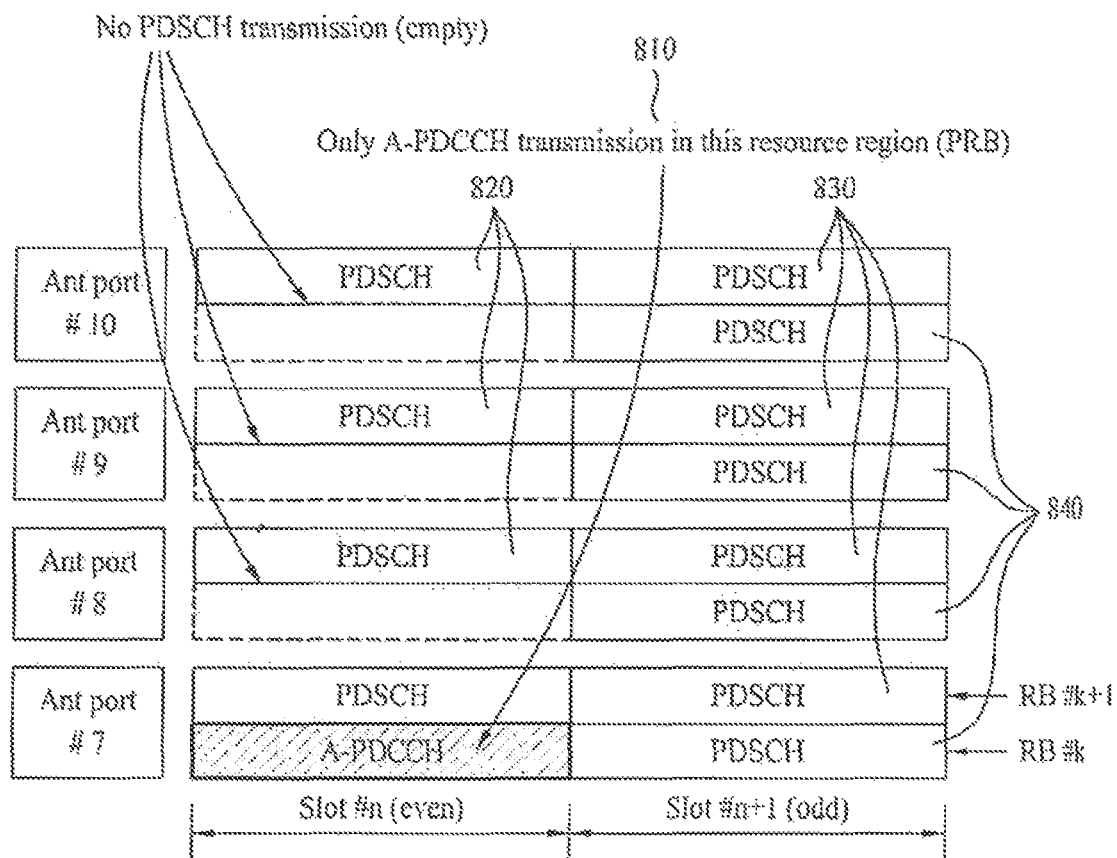


FIG. 8



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# METHOD FOR TRANSMITTING SIGNAL USING PLURALITY OF ANTENNA PORTS AND TRANSMISSION END APPARATUS FOR SAME

## CROSS-REFERENCE TO RELATED APPLICATIONS

This application is the National Stage filing under 35 U.S.C. 371 of International Application No. PCT/KR2012/003678, filed on May 10, 2012, which claims the benefit of U.S. Provisional Application Ser. No. 61/484,665, filed on May 10, 2011, the contents of which are hereby incorporated by reference herein in their entirety.

## FIELD OF THE INVENTION

The present invention relates to wireless communication, and more particularly to a method and apparatus for transmitting a signal using a plurality of antenna ports and a transmission-end apparatus for the method and apparatus.

## BACKGROUND ART

Wireless communication systems have been widely used to provide various kinds of communication services such as voice or data services. Generally, a wireless communication system is a multiple access system that can communicate with multiple users by sharing available system resources (bandwidth, transmission (Tx) power, and the like). A variety of multiple access systems can be used. For example, a Code Division Multiple Access (CDMA) system, a Frequency Division Multiple Access (FDMA) system, a Time Division Multiple Access (TDMA) system, an Orthogonal Frequency Division Multiple Access (OFDMA) system, a Single Carrier Frequency-Division Multiple Access (SC-FDMA) system, a Multi-Carrier Frequency Division Multiple Access (MC-FDMA) system, and the like.

## DETAILED DESCRIPTION OF THE INVENTION

### Technical Problem

Accordingly, the present invention is directed to a method and apparatus for transmitting a signal using a plurality of antenna ports, and a transmission-end apparatus for the same that substantially obviate one or more problems due to limitations and disadvantages of the related art. An object of the present invention is to provide a method for enabling a transmission end supporting signal transmission through a plurality of antenna ports to transmit a signal using the plurality of antenna ports.

Another object of the present invention is to provide a transmission end for transmitting a signal using a plurality of antenna ports.

It is to be understood that technical objects to be achieved by the present invention are not limited to the aforementioned technical objects and other technical objects which are not mentioned herein will be apparent from the following description to one of ordinary skill in the art to which the present invention pertains.

### Technical Solution

The object of the present invention can be achieved by providing a method for transmitting a signal using a plurality of antenna ports by a transmission end configured to support

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signal transmission through the plurality of antenna ports including: transmitting a control channel to a reception end through a first antenna port using a first resource region; and transmitting a data channel to the reception end through a plurality of antenna ports including the first antenna port using a second resource region, wherein the second resource region has the same time domain as the first resource region whereas the second resource region and the first resource region have different frequency domains, and the data channel is not transmitted through the remaining at least one antenna port other than the first antenna port in time and frequency domains corresponding to the first resource region. The control channel is an Advanced-Physical Downlink Control Channel (A-PDCCH) or a Relay-Physical Downlink Control Channel (R-PDCCH), and the data channel is a Physical Downlink Shared Channel (PDSCH). The transmission end is a base station (BS), and the reception end is a user equipment (UE) or a relay. An antenna port index of the first antenna port is set to 7, and an antenna port index of the remaining at least one antenna port includes at least one of 8, 9 and 10. The time domain corresponding to the first resource region corresponds to any one of a symbol unit, a slot unit, and a subframe unit. The frequency domain corresponding to the first resource region corresponds to a Physical Resource Block (PRB) unit.

The method may further include: transmitting indication information regarding a transmission scheme of the A-PDCCH or R-PDCCH to the reception end, wherein the indication information indicates whether the A-PDCCH or R-PDCCH is transmitted in the same time and frequency domains as those of the PDSCH according to a spatial multiplexing (SM) scheme. The indication information is transmitted using RRC signaling, a MAC layer signal, and a PHY (Physical layer) signal. The PHY signal is transmitted through a specific field of a Downlink Control Information (DCI) format or a Control Format Indicator (CFI) field format.

In accordance with another aspect of the present invention, a transmission end for transmitting a signal using a plurality of antenna ports includes: a transmitter configured to transmit a control channel to a reception end through a first antenna port using a first resource region, and transmit a data channel to the reception end through a plurality of antenna ports including the first antenna port using a second resource region, wherein the second resource region has the same time domain as the first resource region whereas the second resource region and the first resource region have different frequency domains, and the data channel is not transmitted through the remaining at least one antenna port other than the first antenna port in time and frequency domains corresponding to the first resource region. The time domain corresponding to the first resource region corresponds to any one of a symbol unit, a slot unit, and a subframe unit. The frequency domain corresponding to the first resource region corresponds to a Physical Resource Block (PRB) unit.

The transmitter is configured to transmit indication information regarding a transmission scheme of the A-PDCCH or R-PDCCH to the reception end, wherein the indication information indicates whether the A-PDCCH or R-PDCCH is transmitted in the same time and frequency domains as those of the PDSCH according to a spatial multiplexing (SM) scheme. The control channel is an Advanced-Physical Downlink Control Channel (A-PDCCH) or a Relay-Physical Downlink Control Channel (R-PDCCH), and the data channel is a Physical Downlink Shared Channel (PDSCH). The

transmission end is a base station (BS), and the reception end is a user equipment (UE) or a relay.

### Effects of the Invention

As is apparent from the above description, the embodiments of the present invention can enable a reception end to improve a decoding throughput of A-PDCCH or R-PDCCH, and can enable a transmission end to transmit A-PDCCH or R-PDCCH using a spatial multiplexing scheme, resulting in increased efficiency of resource usage.

It will be appreciated by persons skilled in the art that the effects that can be achieved with the present invention are not limited to what has been particularly described hereinabove and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings.

### BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention, illustrate embodiments of the invention and together with the description serve to explain the principle of the invention.

FIG. 1 is a block diagram illustrating a transmission end and a reception end for use in a wireless communication system.

FIG. 2 is a diagram illustrating a structure of a radio frame used in a 3GPP LTE system as an exemplary mobile communication system.

FIG. 3 is an exemplary structural diagram illustrating downlink and uplink subframes for use in a 3GPP LTE system as an exemplary mobile communication system.

FIG. 4 shows a downlink (DL) time-frequency resource grid structure for use in a 3GPP LTE system.

FIG. 5 is a conceptual diagram illustrating a legacy PDCCH concept and an A-PDCCH scheme proposed by the embodiment.

FIG. 6 is a conceptual diagram illustrating R-PDCCH for use in PDSCH or PUSCH transmission of a base station (BS) and a relay link.

FIG. 7 is a conceptual diagram illustrating A-PDCCH spatially multiplexed with a PDSCH.

FIG. 8 is a conceptual diagram illustrating A-PDCCH not spatially multiplexed with a PDSCH.

### BEST MODE FOR CARRYING OUT THE INVENTION

Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings. The detailed description, which will be given below with reference to the accompanying drawings, is intended to explain exemplary embodiments of the present invention, rather than to show the only embodiments that can be implemented according to the present invention. The following detailed description includes specific details in order to provide a thorough understanding of the present invention. However, it will be apparent to those skilled in the art that the present invention may be practiced without such specific details. For example, the following description will be given centering upon a mobile communication system serving as a 3GPP LTE or LTE-A system, but the present invention is not limited thereto and the remaining parts of the present invention other than unique characteristics of the 3GPP LTE or LTE-A system are applicable to other mobile communication systems.

In some cases, in order to prevent ambiguity of the concepts of the present invention, conventional devices or apparatuses well known to those skilled in the art will be omitted and be denoted in the form of a block diagram on the basis of important functions of the present invention. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

In the following description, a terminal may refer to a mobile or fixed user equipment (UE), for example, a user equipment (UE), a mobile station (MS) and the like. Also, the base station (BS) may refer to an arbitrary node of a network end which communicates with the above terminal, and may include an eNode B (eNB), a Node B (Node-B), an access point (AP) and the like. Although the embodiments of the present invention are disclosed on the basis of 3GPP LTE, LTE-A systems for convenience of description, contents of the present invention can also be applied to other communication systems.

In a mobile communication system, the UE may receive information from the base station (BS) via a downlink, and may transmit information via an uplink. The information that is transmitted and received to and from the UE includes data and a variety of control information. A variety of physical channels are used according to categories of transmission (Tx) and reception (Rx) information of the UE.

FIG. 1 is a block diagram illustrating a transmission end 105 and a reception end 110 for use in a wireless communication system 100 according to the present invention.

Although FIG. 1 shows one transmission end 105 and one reception end 110 for brief description of the wireless communication system 100, it should be noted that the wireless communication system 100 may further include one or more transmission ends and/or one or more reception ends.

Referring to FIG. 1, the transmission end 105 may include a transmission (Tx) data processor 115, a symbol modulator 120, a transmitter 125, a transmission/reception antenna 130, a processor 180, a memory 185, a receiver 190, a symbol demodulator 195, and a reception (Rx) data processor 197. The reception end 110 may include a Tx data processor 165, a symbol modulator 170, a transmitter 175, a transmission/reception antenna 135, a processor 155, a memory 160, a receiver 140, a symbol demodulator 155, and a Rx data processor 150. In FIG. 1, although one antenna 130 is used for the transmission end 105 and one antenna 135 is used for the reception end 110, each of the transmission end 105 and the reception end 110 may also include a plurality of antennas as necessary. Therefore, the transmission end 105 and the reception end 110 according to the present invention support a Multiple Input Multiple Output (MIMO) system. The transmission end 105 according to the present invention can support both a Single User-MIMO (SU-MIMO) scheme and a Multi User-MIMO (MU-MIMO) scheme.

In downlink, the Tx data processor 115 receives traffic data, formats the received traffic data, codes the formatted traffic data, and interleaves the coded traffic data, and modulates the interleaved data (or performs symbol mapping upon the interleaved data), such that it provides modulation symbols (i.e., data symbols). The symbol modulator 120 receives and processes the data symbols and pilot symbols, such that it provides a stream of symbols.

The symbol modulator 120 multiplexes data and pilot symbols, and transmits the multiplexed data and pilot symbols to the transmitter 125. In this case, each transmission (Tx) symbol may be a data symbol, a pilot symbol, or a value of a zero signal (null signal). In each symbol period, pilot symbols may be successively transmitted during each symbol period. The pilot symbols may be an FDM symbol, an OFDM symbol, a

Time Division Multiplexing (TDM) symbol, or a Code Division Multiplexing (CDM) symbol.

The transmitter **125** receives a stream of symbols, converts the received symbols into one or more analog signals, and additionally adjusts the one or more analog signals (e.g., amplification, filtering, and frequency upconversion of the analog signals), such that it generates a downlink signal appropriate for data transmission through an RF channel. Subsequently, the downlink signal is transmitted to the RN through the antenna **130**. The Tx antenna **130** transmits the generated DL signal to the UE.

Configuration of the reception end **110** will hereinafter be described in detail. The Rx antenna **135** of the reception end **110** receives a DL signal from the transmission end **105**, and transmits the DL signal to the receiver **140**. The receiver **140** performs adjustment (e.g., filtering, amplification, and frequency downconversion) of the received DL signal, and digitizes the adjusted signal to obtain samples. The symbol demodulator **145** demodulates the received pilot symbols, and provides the demodulated result to the processor **155** to perform channel estimation.

The symbol demodulator **145** receives a frequency response estimation value for downlink from the processor **155**, demodulates the received data symbols, obtains data symbol estimation values (indicating estimation values of the transmitted data symbols), and provides the data symbol estimation values to the Rx data processor **150**. The Rx data processor **150** performs demodulation (i.e., symbol-demapping) of data symbol estimation values, deinterleaves the demodulated result, decodes the deinterleaved result, and recovers the transmitted traffic data.

The processing of the symbol demodulator **145** and the Rx data processor **150** is complementary to that of the symbol modulator **120** and the Tx data processor **115** in the transmission end **105**.

The Tx data processor **165** of the reception end **110** processes traffic data in uplink, and provides data symbols. The symbol modulator **170** receives and multiplexes data symbols, and modulates the multiplexed data symbols, such that it can provide a stream of symbols to the transmitter **175**. The transmitter **175** receives and processes the stream of symbols to generate an uplink (UL) signal, and the UL signal is transmitted to the transmission end **105** through the Tx antenna **135**.

The transmission end **105** receives the UL signal from the UE **110** through the antenna **130**. The receiver processes the received UL signal to obtain samples. Subsequently, the symbol demodulator **195** processes the symbols, and provides pilot symbols and data symbol estimation values received via uplink. The Rx data processor **197** processes the data symbol estimation value, and recovers traffic data received from the reception end **110**.

Processor **155** or **180** of the reception end **110** or the transmission end **105** commands or indicates operations of the reception end **110** or the transmission end **105**. For example, the processor **155** or **180** of the reception end **110** or the transmission end **105** controls, adjusts, and manages operations of the reception end **110** or the transmission end **105**. Each processor **155** or **180** may be connected to a memory unit **160** or **185** for storing program code and data. The memory **160** or **185** is connected to the processor **155** or **180**, such that it can store the operating system, applications, and general files.

The processor **155** or **180** may also be referred to as a controller, a microcontroller, a microprocessor, a microcomputer, etc. In the meantime, the processor **155** or **180** may be implemented by various means, for example, hardware, firm-

ware, software, or a combination thereof. In a hardware configuration, methods according to the embodiments of the present invention may be implemented by the processor **155** or **180**, for example, one or more application specific integrated circuits (ASICs), digital signal processors (DSPs), digital signal processing devices (DSPDs), programmable logic devices (PLDs), field programmable gate arrays (FPGAs), processors, controllers, microcontrollers, microprocessors, etc.

In a firmware or software configuration, methods according to the embodiments of the present invention may be implemented in the form of modules, procedures, functions, etc. which perform the above-described functions or operations. Firmware or software implemented in the present invention may be contained in the processor **155** or **180** or the memory unit **160** or **185**, such that it can be driven by the processor **155** or **180**.

Radio interface protocol layers among the reception end **110**, the transmission end **105**, and a wireless communication system (i.e., network) can be classified into a first layer (L1 layer), a second layer (L2 layer) and a third layer (L3 layer) on the basis of the lower three layers of the Open System Interconnection (OSI) reference model widely known in communication systems. A physical layer belonging to the first layer (L1) provides an information transfer service through a physical channel. A Radio Resource Control (RRC) layer belonging to the third layer (L3) controls radio resources between the UE and the network. The reception end **110** and the transmission end **105** may exchange RRC messages with each other through the wireless communication network and the RRC layer. For example, the transmission end **105** may be a base station (BS), and the reception end **110** may be a UE or a relay node (RN). If necessary, the reception end **110** may operate as the BS, and the transmission end **105** may operate as a UE or RN.

FIG. 2 is a diagram illustrating a structure of a radio frame used in a 3GPP LTE system acting as a mobile communication system.

Referring to FIG. 2, the radio frame has a length of 10 ms ( $327200 \times T_s$ ) and includes 10 subframes of equal size. Each subframe has a length of 1 ms and includes two slots. Each slot has a length of 0.5 ms ( $15360 \times T_s$ ). In this case,  $T_s$  represents a sampling time, and is expressed by ' $T_s = 1/(15 \text{ kHz} \times 2048) = 3.2552 \times 10^{-8}$  (about 33 ns)'. The slot includes a plurality of OFDM or SC-FDMA symbols in a time domain, and includes a plurality of resource blocks (RBs) in a frequency domain.

In the LTE system, one resource block includes twelve (12) subcarriers\*seven (or six) OFDM (Orthogonal Frequency Division Multiplexing) symbols. A Transmission Time Interval (TTI) which is a transmission unit time of data can be determined in a unit of one or more subframes. The aforementioned structure of the radio frame is only exemplary, and various modifications can be made to the number of subframes contained in the radio frame or the number of slots contained in each subframe, or the number of OFDM or SC-FDMA symbols in each slot.

FIG. 3 is an exemplary structural diagram illustrating downlink and uplink subframes for use in a 3GPP LTE system as an exemplary mobile communication system according to the present invention.

Referring to FIG. 3(a), one downlink subframe includes two slots in a time domain. A maximum of three OFDM symbols located in the front of the downlink subframe are used as a control region to which control channels are allo-

cated, and the remaining OFDM symbols are used as a data region to which a Physical Downlink Shared Channel (PDSCH) channel is allocated.

DL control channel for use in the 3GPP LTE system includes a Physical Control Format Indicator Channel (PCFICH), a Physical Downlink Control Channel (PDCCH), a Physical Hybrid-ARQ Indicator Channel (PHICH), and the like. The traffic channel includes a Physical Downlink Shared Channel (PDSCH). PCFICH transmitted through a first OFDM symbol of the subframe may carry information about the number of OFDM symbols (i.e., the size of control region) used for transmission of control channels within the subframe. Control information transmitted through PDCCH is referred to as downlink control information (DCI). The DCI may indicate UL resource allocation information, DL resource allocation information, UL transmission power control commands of arbitrary UE groups, etc. PHICH may carry ACK (Acknowledgement)/NACK (Not-Acknowledgement) signals about an UL Hybrid Automatic Repeat Request (UL HARQ). That is, the ACK/NACK signals about UL data transmitted from the UE are transmitted over PHICH.

PDCCH serving as a downlink physical channel will hereinafter be described in detail.

A base station (BS) may transmit information about resource allocation and transmission format (UL grant) of the PDSCH, resource allocation information of the PUSCH, information about Voice over Internet Protocol (VoIP) activation, etc. A plurality of PDCCHs may be transmitted within the control region, and the UE may monitor the PDCCHs. Each PDCCH includes an aggregate of one or more contiguous control channel elements (CCEs). The PDCCH composed of the aggregate of one or more contiguous CCEs may be transmitted through the control region after performing subblock interleaving. CCE is a logical allocation unit for providing a coding rate based on a Radio frequency (RF) channel status to the PDCCH. CCE may correspond to a plurality of resource element groups. PDCCH format and the number of available PDCCHs may be determined according to the relationship between the number of CCEs and the coding rate provided by CCEs.

Control information transmitted over PDCCH is referred to as downlink control information (DCI). The following Table 1 shows DCIs in response to DCI formats.

TABLE 1

DCI Format	Description
DCI format 0	used for the scheduling of PUSCH
DCI format 1	used for the scheduling of one PDSCH codeword
DCI format 1A	used for the compact scheduling of one PDSCH codeword and random access procedure initiated by a PDCCH order
DCI format 1B	used for the compact scheduling of one PDSCH codeword with precoding information
DCI format 1C	used for very compact scheduling of one PDSCH codeword
DCI format 1D	used for the compact scheduling of one PDSCH codeword with precoding and power offset information
DCI format 2	used for scheduling PDSCH to UEs configured in closed-loop spatial multiplexing mode
DCI format 2A	used for scheduling PDSCH to UEs configured in open-loop spatial multiplexing mode
DCI format 3	used for the transmission of TPC commands for PUCCH and PUSCH with 2-bit power adjustments
DCI format 3A	used for the transmission of TPC commands for PUCCH and PUSCH with single bit power adjustments

In Table 1, DCI format 0 may indicate uplink resource allocation information. DCI format 1 and DCI format 2 may

indicate downlink resource allocation information. DCI format 3 and DCI format 3A may indicate uplink transmit power control (TPC) commands for arbitrary UE groups.

A method for allowing a BS to perform resource mapping for PDCCH transmission in the LTE system will hereinafter be described in detail.

Generally, the BS may transmit scheduling allocation information and other control information to the UE over the PDCCH. A physical control channel (PDCCH) is configured in the form of one aggregate (one aggregation) or several CCEs, and is transmitted as one aggregate or several CCEs. One CCE includes 9 resource element groups (REGs). The number of RBGs unallocated to either Physical Control Format Indicator Channel (PCFICH) or Physical Hybrid Automatic Repeat Request Indicator Channel (PHICH) is  $N_{RBG}$ . CCEs from 0 to  $N_{CCE}-1$  may be available to a system (where,  $N_{CCE} = \lceil N_{REG}/9 \rceil$ ). PDCCH supports multiple formats as shown in the following Table 2. One PDCCH composed of  $n$  contiguous CCEs begins with a CCE having 'i mod n=0' (where 'i' is a CCE number). Multiple PDCCHs may be transmitted through one subframe.

TABLE 2

PDCCH format	Number of CCEs	Number of resource-element groups	Number of PDCCH bits
0	1	9	72
1	2	18	144
2	4	36	288
3	8	72	576

Referring to Table 2, an eNode B (eNB) may decide a PDCCH format according to how many regions are required for the BS to transmit control information. The UE reads control information and the like in units of a CCE, resulting in reduction of overhead. Likewise, a relay node (RN) may read control information or the like in units of R-CCE or CCE. In the LTE-A system, a resource element (RE) may be mapped in units of a Relay Control Channel Element (R-CCE) or CCE so as to transmit an R-PDCCH for an arbitrary RN.

Referring to FIG. 3(b), an uplink (UL) subframe may be divided into a control region and a data region in a frequency domain. The control region may be assigned to a Physical Uplink Control Channel (PUCCH) carrying uplink control information (UCI). The data region may be assigned to a Physical Uplink Shared Channel (PUSCH) carrying user data. In order to maintain single carrier characteristics, one UE does not simultaneously transmit PUCCH and PUSCH. PUCCH for one UE may be assigned to a Resource Block (RB) pair in one subframe. RBs of the RB pair occupy different subcarriers in two slots. The RB pair assigned to PUCCH performs frequency hopping at a slot boundary.

FIG. 4 shows a downlink (DL) time-frequency resource grid structure for use in a 3GPP LTE system.

Referring to FIG. 4, downlink transmission resources can be described by a resource grid including  $N_{RB}^{DL} \times N_{SC}^{RB}$  subcarriers and  $N_{symb}^{DL}$  OFDM symbols. Here,  $N_{RB}^{DL}$  represents the number of resource blocks (RBs) in a downlink,  $N_{SC}^{RB}$  represents the number of subcarriers constituting one RB, and  $N_{symb}^{DL}$  represents the number of OFDM symbols in one downlink slot.  $N_{RB}^{DL}$  varies with a downlink transmission bandwidth constructed in a cell, and must satisfy  $N_{RB}^{min,DL} \leq N_{RB}^{DL} \leq N_{RB}^{max,DL}$ . Here,  $N_{RB}^{min,DL}$  is the smallest downlink bandwidth supported by the wireless communication system, and  $N_{RB}^{max,DL}$  is the largest downlink bandwidth supported by the wireless communication system. Although  $N_{RB}^{min,DL}$  may be set to 6 ( $N_{RB}^{min,DL}=6$ ) and

$N_{RB}^{max,DL}$  may be set to 110 ( $N_{RB}^{max,DL}=110$ ), the scopes of  $N_{RB}^{min,UL}$  and  $N_{RB}^{max,UL}$  are not limited thereto. The number of OFDM symbols contained in one slot may be differently defined according to the length of a Cyclic Prefix (CP) and spacing between subcarriers. When transmitting data or information via multiple antennas, one resource grid may be defined for each antenna port.

Each element contained in the resource grid for each antenna port is called a resource element (RE), and can be identified by an index pair (k,l) contained in a slot, where k is an index in a frequency domain and is set to any one of  $0, \dots, N_{RB}^{DL}N_{sc}^{RB}-1$ , and l is an index in a time domain and is set to any one of  $0, \dots, N_{symb}^{DL}-1$ .

Resource blocks (RBs) shown in FIG. 4 are used to describe a mapping relationship between certain physical channels and resource elements (REs). The RBs can be classified into physical resource blocks (PRBs) and virtual resource blocks (VRBs). One PRB is defined by  $N_{symb}^{DL}$  consecutive OFDM symbols in a time domain and  $N_{sc}^{RB}$  consecutive subcarriers in a frequency domain.  $N_{symb}^{DL}$  and  $N_{sc}^{RB}$  may be predetermined values, respectively. For example,  $N_{symb}^{DL}$  and  $N_{sc}^{RB}$  may be given as shown in the following Table 1. Therefore, one PRB may be composed of  $N_{symb}^{DL} \times N_{sc}^{RB}$  resource elements. One PRB may correspond to one slot in a time domain and may also correspond to 180 kHz in a frequency domain, but it should be noted that the scope of the present invention is not limited thereto.

TABLE 3

Configuration		$N_{sc}^{RB}$	$N_{symb}^{DL}$
Normal cyclic prefix	$\Delta f = 15$ kHz	12	7
Extended cyclic prefix	$\Delta f = 15$ kHz		6
	$\Delta f = 7.5$ kHz	24	3

The PRBs are assigned numbers from 0 to  $N_{RB}^{DL}-1$  in the frequency domain. A PRB number  $n_{PRB}$  and a resource element index (k,l) in a slot can satisfy a predetermined relationship denoted by

$$n_{PRB} = \left\lfloor \frac{k}{N_{sc}^{RB}} \right\rfloor.$$

The VRB may have the same size as that of the PRB. The VRB may be classified into a localized VRB (LVRB) and a distributed VRB (DVRB). For each VRB type, a pair of PRBs allocated over two slots of one subframe is assigned a single VRB number  $n_{VRB}$ .

The VRB may have the same size as that of the PRB. Two types of VRBs are defined, the first one being a localized VRB (LVRB) and the second one being a distributed type (DVRB). For each VRB type, a pair of PRBs may have a single VRB index (which may hereinafter be referred to as a 'VRB number') and are allocated over two slots of one subframe. In other words,  $N_{RB}^{DL}$  VRBs belonging to a first one of two slots constituting one subframe are each assigned any one index of 0 to  $N_{RB}^{DL}-1$ , and  $N_{RB}^{DL}$  VRBs belonging to a second one of the two slots are likewise each assigned any one index of 0 to  $N_{RB}^{DL}-1$ .

The radio frame structure, the downlink subframe, the uplink subframe, and the downlink time-frequency resource grid structure shown in FIGS. 2 to 4 may also be applied between a base station (BS) and a relay node (RN).

A method for allowing the BS to transmit a PDCCH to a user equipment (UE) in an LTE system will hereinafter be described in detail. The BS determines a PDCCH format according to a DCI to be sent to the UE, and attaches a Cyclic Redundancy Check (CRC) to control information. A unique identifier (e.g., a Radio Network Temporary Identifier (RNTI)) is masked onto the CRC according to PDCCH owners or utilities. In case of a PDCCH for a specific UE, a unique ID of a user equipment (UE), for example, C-RNTI (Cell-RNTI) may be masked onto CRC. Alternatively, in case of a PDCCH for a paging message, a paging indication ID (for example, R-RNTI (Paging-RNTI)) may be masked onto CRC. In case of a PDCCH for system information (SI), a system information ID (i.e., SI-RNTI) may be masked onto CRC. In order to indicate a random access response acting as a response to an UE's random access preamble transmission, RA-RNTI (Random Access—RNTI) may be masked onto CRC. The following Table 4 shows examples of IDs masked onto PDCCH and/or R-PDCCH.

TABLE 4

Type	Identifier	Description
UE-specific Common	C-RNTI	used for the UE corresponding to the C-RNTI.
	P-RNTI	used for paging message.
	SI-RNTI	used for system information (It could be differentiated according to the type of system information).
	RA-RNTI	used for random access response (It could be differentiated according to subframe or PRACH slot index for UE PRACH transmission).
	TPC-RNTI	used for uplink transmit power control command (It could be differentiated according to the index of UE TPC group).

If C-RNTI is used, PDCCH may carry control information for a specific UE, and R-PDCCH may carry control information for a specific RN. If another RNTI is used, PDCCH may carry common control information that is received by all or some UEs contained in the cell, and R-PDCCH may carry common control information that is received by all or some RNs contained in the cell. The BS performs channel coding of the CRC-added DCI so as to generate coded data. The BS performs rate matching according to the number of CCEs allocated to a PDCCH or R-PDCCH format. Thereafter, the BS modulates the coded data so as to generate modulated symbols. In addition, the BS maps the modulated symbols to physical resource elements.

The embodiment of the present invention proposes a method for applying the spatial multiplexing scheme to a control channel (for example, Advanced PDCCH (A-PDCCH), Enhanced PDCCH, ePDCCH, etc.) obtained by improvement of a PDCCH channel serving as a control channel of the legacy 3GPP LTE system. In addition, the spatial multiplexing scheme applied to the improved control channel may be equally applied to a Relay-Physical Downlink Control Channel (R-PDCCH) of the 3GPP LTE-A system unless otherwise mentioned. Here, R-PDCCH may be referred to as a backhaul physical downlink control channel for relay transmission from the BS to the RN, and is used as a control channel for the RN.

FIG. 5 is a conceptual diagram illustrating a legacy PDCCH concept and an A-PDCCH scheme proposed by the embodiment.

Referring to FIG. 5(a), a PDCCH region 510 is allocated to one subframe, and downlink control information (for example, DL grant, UL grant, etc.) received from the PDCCH

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region **510** relates to a PDSCH **520** contained in the same subframe. The processor **155** of the UE may decode a PDSCH region **520** on the basis of DL control information received from the PDCCH **510** so as to acquire data.

Referring to FIG. **5(b)**, A-PDCCH **540** may be allocated to the PDSCH region serving as a data reception region in the legacy LTE system. A-PDCCH **540** may carry DL scheduling assignment information for PDSCH **1 (550)** and a Physical Uplink Shared Channel (PUSCH) UL scheduling grant. Generally, upon PDCCH **530** is not received, the A-PDCCH **540** may be transmitted on the basis of a UE-specific reference signal.

The UE may simultaneously receive the A-PDCCH **540** and the PDCCH **530**, and may decode PDSCH **1 (550)** upon receiving an additional assistance of the PDCCH **530**. Referring to FIG. **5(b)**, the A-PDCCH **540** may be FDM-processed along with PDSCH **1 (550)** and PDSCH **2 (560)** within a data region of the legacy LTE system.

In order to obtain a beamforming gain, the BS may apply precoding to DM RS (DeModulation Reference Signal)-based A-PDCCH **540**. The UE may decode the A-PDCCH on the basis of a DM RS. In this case, a reference signal (RS) for use in the LTE-A system will hereinafter be described in detail.

One important consideration in designing an LTE-A system is backward compatibility. Backward compatibility is the ability to support existing LTE UEs such that the LTE UEs properly operate in the LTE-A system. If RSs for up to 8 transmit antennas are added to time-frequency domains in which a CRS defined in the LTE standard is transmitted every subframe over an entire band, RS overhead is excessively increased from the viewpoint of RS transmission. That is, assuming that RS patterns for up to 8 Tx antennas are added to each subframe of the entire band in the same manner as in CRS of legacy LTE, RS overhead excessively increases. Therefore, there is a need to take into consideration RS overhead reduction when designing new RSs for up to 8 antenna ports. RSs newly introduced in the LTE-A system may be largely classified into two types. One is a DeModulation RS (DM RS) which is an RS for demodulating data transmitted through up to 8 transmit antennas. The other is a Channel State Information RS (CSI-RS) which is an RS for channel measurement for selection of a Modulation and Coding Scheme (MCS), a Precoding Matrix Index (PMI), or the like. The CSI-RS for channel measurement is characterized in that the CSI-RS is designed mainly for channel measurement unlike the CRS of the conventional LTE system which is used not only for measurement of handover or the like but also for data modulation. Of course, the CSI-RS may also be used for measurement of handover or the like. Since the CSI-RS is transmitted only for the purpose of obtaining information regarding channel conditions, the CSI-RS need not be transmitted every subframe, unlike the CRS of the conventional LTE system. Accordingly, to reduce CSI-RS overhead, the CSI-RS may be designed to be transmitted intermittently (periodically) in the time axis. For data demodulation, DM-RS is transmitted to a UE scheduled in the corresponding time-frequency domain. That is, DM-RS of a specific UE is transmitted only to a scheduled region (i.e., a time-frequency region for data reception) of the corresponding UE.

FIG. **6** is a conceptual diagram illustrating R-PDCCH for use in PDSCH or PUSCH transmission of a base station (BS) and a relay link.

Referring to FIG. **6**, R-PDCCH **610** need not be constructed in units of a slot in the legacy LTE system. R-PDCCH **610** may carry DL scheduling assignment information of PDSCH **1 630**, and a UL scheduling grant for a Physical

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Uplink Shared Channel (PUSCH). A relay or RN may decode the R-PDCCH **61-0** using a DM RS.

FIG. **7** is a conceptual diagram illustrating A-PDCCH spatially multiplexed with a PDSCH.

Referring to FIG. **7**, A-PDCCH (or R-PDCCH) may be SM (Spatial Multiplexing)-processed or MLT (Multiple Layer Transmission)-processed as necessary. The transmission end (where, if A-PDCCH is transmitted, the transmission end may be a BS; and if R-PDCCH is transmitted, the transmission end may be a relay or RN) may perform spatial multiplexing of A-PDCCH and PDSCH using different antenna ports at a specific resource region **710** (for example, a first slot of the k-th RB (RB #k)). For example, the BS may transmit the A-PDCCH to the antenna port #7, and at the same time PDSCH can be transmitted through the antenna ports (#8, #9, #10) in the specific resource region **710**. Although FIG. **7** exemplarily shows that A-PDCCH is transmitted through the n-th slot (Slot #n) for convenience of description, it should be noted that the A-PDCCH can be transmitted not only to Slot #n but also to Slot #n+1. Preferably, the BS may transmit the A-PDCCH through two slots (#n, #n+1).

As can be seen from FIG. **7**, four-layer transmission is carried out at a specific RB (or PRB) pair (i.e., Slot #n, Slot #n+1), and A-PDCCH and PDSCH are SM-transmitted at two contiguous PRBs (i.e., RB #k, RB #k+1) in a frequency domain. In this case, in order to extend a resource region (band) for PDSCH transmission, although the transmission end transmits A-PDCCH or R-PDCCH to Antenna Port #7 and RB #k, PDSCH transmission is carried out at RB #k of the antenna ports (#8, #9, #10).

As described above, the spatial multiplexing (SM) scheme is applied to the transmission end so as to simultaneously transmit A-PDCCH and PDSCH, such that much more information can be transmitted within a restricted resource region whereas interference between antenna ports or layers occurs. Therefore, in order to implement high efficiency of resource usage, special-purposed interference cancellation must be used to remove a sufficient amount of undesired interference components between layers. However, in order to smoothly perform the above operation, the system may preferably pre-recognize the presence or absence of another layer or antenna port.

However, the transmission end may simultaneously transmit A-PDCCH and PDSCH using the spatial multiplexing (SM) scheme, such that A-PDCCH throughput may be deteriorated due to interference problem or power distribution problem.

FIG. **8** is a conceptual diagram illustrating A-PDCCH not spatially multiplexed with a PDSCH.

Referring to FIG. **8**, the transmission end (for example, BS or RN) may use the spatial multiplexing (SM) scheme between PDSCH layers, and may independently transmit only the A-PDCCH without using the spatial multiplexing (SM) scheme in a resource region (for example, PRB or PRB pair) to which the A-PDCCH is transmitted. As a result, the resource use efficiency may be slightly deteriorated, and A-PDCCH decoding throughput of the reception end (for example, UE) may be greatly improved.

FIG. **8** shows A-PDCCH or R-PDCCH in which the spatial multiplexing (RM) scheme is not used. While the transmission end transmits the A-PDCCH using the antenna port #7 at a specific resource region **810** (for example, slot #n, RB #k), PDSCH may not be transmitted in the corresponding resource region **810** through the antenna ports (#8, #9, #10).

As can be seen from FIG. **8**, a specific resource region **810** is identical to a time domain, and the transmission end may transmit a PDSCH using the antenna ports (#8, #9, #10) or



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may simultaneously transmit A-PDCCH or R-PDCCH using the antenna ports (#8, #9, #10) in a resource region 820 corresponding to another frequency domain. The transmission end may not allocate the A-PDCCH to the slot #n+1, such that the transmission end may transmit a PDSCH to the reception end through a plurality of antenna ports (i.e., a plurality of antenna ports from among the antenna ports #7, #8, #9, #10) within each of the resource region 830 and the other resource region 840.

Although FIG. 8 exemplarily shows that A-PDCCH or R-PDCCH is allocated in units of a slot, the scope or spirit of the present invention is not limited thereto, the A-PDCCH or R-PDCCH may be transmitted through a plurality of symbols from among the remaining symbols other than symbols (to which PDSCH is allocated) within a subframe.

Although the above-mentioned two A-PDCCH transmission methods may be used independently from each other, it should be noted that the two methods may be simultaneously applied to the UE or RN. That is, it is more preferable that spatial multiplexing (SM) A-PDCCH be used according to an experience situation of UE/RN and a system, or it is more preferable that non-SM A-PDCCH be used.

Therefore, the present invention provides a method for selectively using the above two methods or combining the above two methods as necessary. Information indicating which method will be selected/used may be transmitted to the UE or RN through RRC signaling. Such indication signal is provided, the UE and RN may operate an appropriate receiver algorithm according to the selected method, such that an optimum demodulation performance can be obtained.

The embodiment may use not only RRC (Radio Resource Control) signaling but also MAC layer signaling and PHY layer signaling. For example, the embodiment may indicate which method is used/transmitted using a specific field (bit) of a DCI format. If the value of 0 is established using LVRB/DVRB bits from among the DCI format field of R-PDCCH, this means a non-SM R-PDCCH. If the value of 1 is established using LVRB/DVRB bits from among the DCI format field of R-PDCCH, the BS may inform the RN of the use of SM R-PDCCH. Of course, if the value of 0 is established, the BS may inform the RN of the use of SM R-PDCCH; and if the value of 1 is established, this means a non-RM R-PDCCH. The LVRB/DVRB indication bit may be only exemplary, and may use another field or another reserved status. Alternatively, the above information may be transmitted using a Control Format Indicator (CFI) field.

In accordance with the above-mentioned embodiments, the decoding throughput of A-PDCCH or R-PDCCH at the reception end may be improved. The transmission end may transmit A-PDCCH or R-PDCCH using the spatial multiplexing (SM) scheme, such that the resource use efficiency can be increased.

The antenna port described in the above embodiment may also be referred to as a port, a layer, a rank, etc. The scope or spirit of the present invention is not limited to indices of the antenna ports shown in the embodiment, and the indices of the antenna ports may be re-numbered as necessary without difficulty.

It will be appreciated by persons skilled in the art that the objects that can be achieved by the present invention are not limited to what has been particularly described hereinabove and the above and other objects that the present invention can achieve will be more clearly understood from the foregoing detailed description taken in conjunction with the accompanying drawings. The exemplary embodiments described hereinabove are combinations of elements and features of the present invention. The elements or features may be consid-

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ered selective unless otherwise mentioned. Each element or feature may be practiced without being combined with other elements or features. Further, the embodiments of the present invention may be constructed by combining parts of the elements and/or features. Operation orders described in the embodiments of the present invention may be rearranged. Some constructions or characteristics of any one embodiment may be included in another embodiment and may be replaced with corresponding constructions or characteristics of another embodiment. It is apparent that the present invention may be embodied by a combination of claims which do not have an explicitly cited relation in the appended claims or may include new claims by amendment after the application is filed.

It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the spirit or scope of the invention. Therefore, the above-mentioned detailed description must be considered for illustrative purposes only, not restrictive purposes. The scope of the present invention must be decided by a rational analysis of the claims, and all modifications within equivalent ranges of the present invention are within the scope of the present invention.

#### INDUSTRIAL APPLICABILITY

As is apparent from the above description, a method for transmitting a signal using a plurality of antenna ports and a transmission end for the same according to the embodiments of the present invention can be applied to various mobile communication systems, for example, 3GPP LTE, LTE-A, IEEE 802, and the like.

The invention claimed is:

1. A method for transmitting signals using a plurality of antenna ports by a transmission end in a wireless communication system, the method comprising:

transmitting a control channel to a reception end through only a first antenna port among the plurality of antenna ports on a first slot of a first resource region having a respective first and second slot,

wherein the control channel indicates a second resource region to be used for transmitting a data channel, the second resource region having a respective first and second slot; and

transmitting the data channel to the reception end through the plurality of antenna ports, including the first antenna port,

wherein, if a portion of the second resource region is overlapped with the first resource region, the data channel is transmitted through the plurality of antenna ports including the first antenna port in a second slot of the first resource region while not being through any of the plurality of antenna ports including the first antenna port in the first slot of the first resource region.

2. The method according to claim 1, wherein the control channel is an Advanced-Physical Downlink Control Channel (A-PDCCH) or a Relay Physical Downlink Control Channel (R-PDCCH), and the data channel is a Physical Downlink Shared Channel (PDSCH).

3. The method according to claim 2, wherein the transmission end is a base station (BS) and the reception end is a user equipment (UE) or a relay node (RN).

4. The method according to claim 1, wherein:

an antenna port index of the first antenna port is set to 7, and an antenna port indexes of the plurality of the antenna ports include 7, 8, 9 and 10.

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5. The method according to claim 1, wherein the data channel is also transmitted through the plurality of antenna ports including the first antenna port in a first slot and a second slot of a region which is not overlapped with the first resource region within the second region.

6. The method according to claim 1, wherein the first resource region corresponds to a Resource Block (RB) pair and the second resource region corresponds to at least one RB pair.

7. The method according to claim 1, wherein the first resource region corresponds to a Resource Block (RB) pair and the second resource region corresponds to at least one RB pair.

8. A transmission end for transmitting signals using a plurality of antenna ports in a wireless communication system, the transmission end comprising:

a transmitter configured to:

transmit a control channel to a reception end through only a first antenna port among the plurality of antenna ports on a first slot of a first resource region having a respective first and second slot,

wherein the control channel indicates a second resource region to be used for transmitting a data channel, the second resource region having a respective first and second slot, and

transmit the data channel to the reception end through the plurality of the antenna ports, including the first antenna port,

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wherein, if a portion of the second resource region is overlapped with the first resource region in a specific time-frequency region, the data channel is transmitted through the plurality of antenna ports including the first antenna port in a second slot of the first resource region while not being through any of the plurality of antenna ports including the first antenna port in the first slot of the first resource region.

9. The transmission end according to claim 8, wherein the control channel is an Advanced-Physical Downlink Control Channel (A-PDCCH) or a Relay Physical Downlink Control Channel (R-PDCCH), and the data channel is a Physical Downlink Shared Channel (PDSCH).

10. The transmission end according to claim 9, wherein the transmission end is a base station (BS), and the reception end is a user equipment (UE) or a relay node (RN).

11. The transmission end according to claim 8, wherein: an antenna port index of the first antenna port is set to 7, and an antenna port indexes of the plurality of the antenna ports include 7, 8, 9 and 10.

12. The method according to claim 8, wherein the data channel is also transmitted through the plurality of antenna ports including the first antenna port in a first slot and a second slot of a region which is not overlapped with the first resource region within the second region.

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